It has been said that in making scientific and technological advances, each generation of scientists and engineers stands on the shoulders of the previous generation. This is true of all types of exploration, and it is true with the Cassini–Huygens mission.

On the Shoulders of Giants

The story begins in late 1609, when Galileo Galilei built a telescope and had the inspiration to aim it at the sky. Galileo's discoveries about the Moon, Venus, Jupiter and the Milky Way were a quantum leap forward in our understanding of the universe, but he was puzzled by Saturn. With his telescope's poor optics, Galileo could only see that Saturn looked like a "triple" planet. To add to the mystery, the planet lost its "companions" a few years later!

Fast forward more than 40 years: Christiaan Huygens turned his telescope toward Saturn and discovered a real companion to the planet – like the four discovered around Jupiter by Galileo – a satellite now called Titan. Huygens also recognized for the first time the great ring surrounding Saturn. He realized that the plane of the ring is tilted with respect to the plane of the planet's orbit, so that about every 14 years, Earth crosses through the plane and the ring can disappear temporarily – explaining Galileo's puzzling observation. Shortly thereafter, Jean-Dominique Cassini discovered four additional satellites and spied a "gap" in the ring, making it two rings separated by what is now called the Cassini division.

Over the next century, more satellites were discovered. And two centuries later, James Clerk Maxwell, well-known for his explanation of electromagnetism, showed that the rings were not solid disks but were instead composed of myriad particles, each in its own orbit. Astrophysical techniques, in development since the 1860s, enabled in 1932 the discovery of methane and ammonia in Saturn's atmosphere – and thus a great advancement in understanding the nature of Saturn and the other "gas giants" – Jupiter, Uranus and Neptune. This was followed by Gerard Kuiper's surprising discovery in 1943–44 of a dense atmosphere, unknown among other planetary satellites, on Titan.

The birth of space exploration in 1957, and the National Aeronautics and Space Administration in 1958, led to dreams of human and robotic exploration of the planets. The wanderlust of the Renaissance was reborn as both scientists

and the public became interested in visiting distant worlds. Ground-based planetary astronomy experienced a rebirth, as new techniques and the need for more information about the planets to be explored pushed the science along.

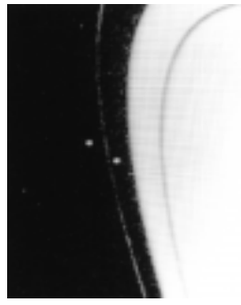
The evolution of planetary exploration began with the first steps to the Moon, was followed by the exploration of Venus and Mars and continued in plans for exploring the outer planets (that is, Jupiter and beyond). Fanciful "Grand Tour" missions to the outer planets were proposed. Pioneers 10 and 11 explored Jupiter and its environment in 1973 and 1974, respectively. The success of Pioneer 10 permitted the retargetting, after Jupiter, of Pioneer 11 to arrive at Saturn in 1979, just as Voyager 1 was arriving at Jupiter.

The Voyagers, 1 and 2, carried out a thorough reconnaissance of Jupiter and then Saturn. Following the success at Saturn, Voyager 2 was able to complete the Grand Tour, missing only tiny Pluto in its travels.

The contributions of these missions, complemented by the continuing developments of science and technology, have brought us to the Cassini–Huygens mission. We can only guess, and not well, at what the Cassini–Huygens spacecraft will find. Surely, many questions raised by previous observations will be answered. But the answers, as always in science, will only generate more questions. And, it is safe to predict there will be some unimaginable surprises.

Technology – the Bridge from the Ethereal to the Material

As technology has improved through history, our understanding of natural phenomena has also improved. And, this technology has affected our daily lives. Improved telescopes provided more knowledge about Saturn and Titan, generating more questions – which drove the development of technology in optics. This has not only helped us do remote-sensing science better, it has allowed eyeglass wearers to see better, via improved lens materials and coatings.



The development of auxiliary instruments changed astronomy from a descriptive science into a "measuring" science, uncovering new mysteries for us to puzzle over, like Titan's atmosphere. Improvements in detectors, from eyeballs through photography to electronic imagers, have made possible the permanent, unbiased recording of images. Digitized images can be transmitted, without loss of detail, across the solar system – and soon, directly into your home, with the image quality on your television matching that in a movie theater.

Advancements in detectors and image-analysis software have been applied in diverse areas: helping patients with limited night vision "see" in the dark; enabling doctors to analyze magnetic resonance, positron emission and X-ray images; and protecting airport personnel from exposure to radiation from security devices.

Developments tied to the Cassini–Huygens mission have had an effect on everyday life. The solid-state recorder, using silicon chips to store data, has found application on other spacecraft and in whole industries, from aerospace to entertainment. Powerful computer chips and a radio transponder from the mission are being used in other spacecraft, providing better performance and lowering overall cost. Solid-state power switches developed for the mission can be used in electrical and electronic products for both industry and consumers.

A new resource-trading exchange permits subsystems on the Cassini–Huygens spacecraft to help balance conflicting needs. It delegates any decisions to those who understand the problem best, so better decisions result. Already, this system has been used by California's South Coast Air Quality Management District to help regulate air pollution; the state of Illinois is adapting it to manage volatile organic wastes.

The Cassini Management Information System tracks a myriad of receivables and deliverables by establishing "contracts" among those involved. Critical steps and objects are easier to identify – and problems can be identified earlier, so they can be addressed more easily and with less expense.

The Cassini–Huygens mission involves hundreds of scientists, engineers and technicians from 17 countries. Learning to cooperate and work together toward a common goal is good practice, for technicians as well as governments. International cooperation distributes the expense among the partner nations and gives them all the opportunity to participate in the adventure and the science. More people with different backgrounds than ever before will share in the direct and derived benefits from this mission.

Space exploration inspires us to look beyond our everyday existence and to the greater universe. We come into this world as explorers, engineers and scientists, learning initially by taste and feel and going on, first crawling, then walking, then running – as the preceding generations try to keep up! – to see and experience the world around us. Exploration is instinctive in us; the Cassini–Huygens mission is another way for us to extend our senses physically to new places and over a broader range of phenomena.

Beautiful Saturn, with its rings, its moons and its many other wonders, beckons to us to explore and uncover its secrets, to partake in the thrill of discovery. Cassini–Huygens is the vehicle.